Made Poorer by Choice:

Worker Outcomes in Social Security v. Private Retirement Accounts

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September 3, 2015

Comments welcome.

We appreciate the comments of On Amir, Alexandre Baptista, Sebastien Betermeier, Hank Bessembinder, Paul Gerrans, Frank de Jong, Matti Keloharju, Alicia Munnell, Arun Muralidhar, Diane Oakley, Jonathan Parker, and seminar participants at the 2015 Gutmann Center Symposium, 2014 AFA Meetings, 2014 EFA Meetings, Arizona State, the Boulder Summer Conference on Consumer Financial Decision Making, the Cleveland Federal Reserve, Drexel, the Federal Reserve Board, Econometric Society, George Washington, Helsinki Finance Summit, the SEC, UT Dallas, and the Western Economic Association. We gratefully acknowledge financial support from the Center for Retirement Research at Boston College and the Sandell Grant Program. The views in this paper are those of the authors and do not necessarily represent the views of the Federal Reserve Board of Governors or its staff.

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Abstract

Can the freedom to choose how retirement funds are invested leave workers worse off? Via simulation, we document that choice in stock v. bond allocation and type of equity investments in private accounts leads to lower utility and greater risk of income shortfalls relative to private accounts without choice. We also compare private account outcomes to currently promised Social Security benefits to demonstrate that a representative worker (an average wage earner) benefits more from private-account alternatives—with or without choice—than do most workers. Thus, representative worker outcome should not be used to assess population-wide benefits of private account alternatives.

> We can never insure one hundred percent of the population against one hundred percent of the hazards and vicissitudes of life, but we have tried to frame a law which will give some measure of protection to the average citizen and to his family against the loss of a job and against poverty-ridden old age.
>
> President Franklin Delano Roosevelt at signing of 1935 Social Security Act

Social security benefits are a modest but important source of retirement income for millions of Americans. In 2013, 37 million retired workers received an average annual Social Security benefit of about $15,000. Among those over age 65, 26% or more than 9 million retirees rely on Social Security for more than 90% of their income. Among those over age 65 and in the bottom quintile of income, 45% rely on Social Security as their sole source of income, while 65% rely on Social Security for more than 90% of their income.[1]

Under the current system, payroll tax receipts fund retiree benefits, and assets are invested in special obligation treasury bonds (Gross 2010). Throughout most of Social Security's history, payroll tax inflows have exceeded benefit outflows. In 2010, benefits exceeded payroll taxes, and this funding deficit is expected to worsen in the coming decades absent reform.

Many strategies have been proposed in response to Social Security's pending shortfall. These range from increases in the payroll tax and retirement age to privatization of Social Security. In 2001, the President's Commission to Strengthen Social Security proposed three models for Social Security reform which all incorporated voluntary personal accounts. Possible Social Security reform repeatedly emerges during major election cycles, along with recommendations featuring some form of private retirement accounts (PRAs).

In addition to suggesting that PRAs would earn high returns, some proponents argue they benefit workers by allowing them to choose how their retirement savings are invested. This is consistent with standard finance theory, where having more choices can only improve potential investment outcomes. However, to realize this improvement, investors must choose investments wisely. In the context of PRAs, there are two relevant issues. First, there is evidence that many investors do not choose portfolio allocations that maximize their utility. For example, default options heavily influence the stock allocation choices of investors (e.g., Beshears, Choi, Laibson, and Madrian 2008, 2009) and choice framing (Benartzi and Thaler 2001, 2007). In addition, many investors fail to participate in stock markets or allocate only a small fraction of their financial assets to equities (see Campbell 2006 for a review). Thus, meaningful analysis of PRA outcomes should consider the impact of allocation choice on potential

[1] Income of the Population 55 or Older, 2010, SSA Publication No. 13-11871, Table 9.B6, p.309. Among those in the bottom quintile of net worth (including home ownership), the present value of Social Security benefits represents 82% of total wealth (Brady, Burham, and Hold (2013), Figure 16, p.35).

outcomes. Second, extant evidence suggests that many investors fail to effectively diversify within their equity portfolios (Barber and Odean 2000; Calvet, Campbell, and Sodini 2009; Goetzman and Kumar 2008; Gaudeker 2015). If this tendency extends to PRAs, outcomes for retirees become more dispersed, and the likelihood of shortfalls relative to currently-promised Social Security benefits increases. Allocation choice and equity choice impart decision risk that materially affects the risk of worker outcomes in a PRA system.

In this paper, we analyze the effects of decision risk on workers' outcomes under a PRA system. We simulate retirement benefits for a representative cohort of 3,655 workers born in the US in 1979. The wages, demographic characteristics, and mortality of our cohort are generated by CORSIM, a dynamic micro-simulation model of the United States population.[2] We compare results from a baseline setting without investment choice to settings in which workers can choose their allocation to stocks and bonds, to equity investments within their stock portfolio, or both. In the baseline scenario (without investment choice), workers are required to invest 50% of their PRA in a stock index and 50% in a bond index during their savings years.[3] In the scenario with allocation choice, workers are allowed to choose an equity allocation that they retain throughout their working years. We calibrate variation in allocation to equities using variation in stock-bond allocations in the 2010 Survey of Consumer Finances. In the scenario with equity choice, workers are allowed to choose their stock investments while bond investments remain indexed. To calibrate the cross-sectional variability of equity investment outcomes, we estimate cross-sectional variation in returns earned in tax-deferred retirement accounts using data from a large U.S. discount brokerage. In each scenario we consider, we require workers to invest in the same (50/50) variable annuity at retirement. We assume this portfolio earns an average return of 7.6%, which is roughly in line with expected returns used by major state pension funds across the US (Novy-Marx and Rauh 2008) and long-term return forecasts used by defined-benefit plans in the US based on survey evidence from Aon Hewitt Inc. (2014). We assume market volatility is equal to its historical average.

In our main results, we compare the utility of workers in PRA systems, where the PRA systems that we consider have varying levels of investment choice, and under a Social Security type retirement system. To compare systems, we assume workers have a time-additive constant relative risk aversion (CRRA) utility over retirement income and compare the expected utility for each worker of retirement

[2] CORSIM was developed by Steven Caldwell at Cornell University. The model was purchased by the U.S. Social Security Administration, which adapted it for internal use under the name POLISIM. The model was also adapted for use by the Canadian and Swedish governments (see Caldwell 1996, Caldwell and Morrison 2000, and http://www.strategicforecasting.com/corsim/index.html).

[3] We do not claim that a 50/50 stock/bond portfolio is the optimal asset allocation. We choose this mix as a benchmark for two reasons. It is close to the median allocation reported in the Survey of Consumer Finances and was the benchmark used in the 2001 Report of the President's Commission on Strengthening Social Security and Creating Personal Wealth for Americans.

benefits under the current Social Security system (SS benefit) to the expected utility of simulated payouts he would expect if his social security taxes were diverted to a private retirement account (PRA income). We then contrast the utility, under different retirement systems, of a representative worker to the utilities of the population of workers.

Two main results emerge from this analysis. First, analyses based on the outcomes of a representative worker are misleading. Several studies of Social Security focus on the welfare of a representative worker (e.g., Auerbach and Kotlikoff (1987), Feldstein and Ranguelova (2001)). Our utility analysis indicates PRAs are much more appealing to the representative worker than to a worker who does not yet know his future income. Specifically, we compare the utility of a representative worker, who earns the average wage of his cohort in each year of his life, to that of a worker who has an equal probability of earning the lifetime income of each member of his cohort (and who we refer to as a worker at birth). We find the representative worker would be indifferent between Social Security and a PRA system without choice at a risk aversion parameter of 5.65; with allocation and investment choice, this indifference risk aversion parameter drops to 2.38. In contrast, a worker at birth has a much stronger preference for Social Security over a PRA system and, consequently, is indifferent between Social Security and a PRA system at much lower levels of risk aversion (1.78 without choice and 1.32 with allocation and investment choice) than is the representative worker.

To assess the economic significance of the differences in the breakeven risk aversion parameters of the representative investors vs. the worker at birth, we engage in the following thought exercise: Assume that the worker at birth is endowed with the breakeven risk aversion parameter of the representative worker. By how much could Social Security payments be reduced for the worker at birth before he prefers PRAs to Social Security? We find that the worker at birth would require a reduction in Social Security payments greater than 61% before he would prefer PRAs to Social Security.

PRAs appeal to the representative worker for three reasons: (1) The representative worker faces no income uncertainty. (2) His annual salaries are higher than median annual salaries. Thus, he doesn't benefit from the progressivity of Social Security's benefits, and (3) he works for 47 years. Thus he saves for 47 years in a PRA, but only 35 of these years contribute to his Average Indexed Monthly Earnings, the basis for calculating Social Security benefits. This result demonstrates the shortcoming of analyses that focus on the benefits of PRAs to the representative worker since such analyses do not account for the uncertainty of lifetime income paths or skewness in the distribution of lifetime income.

The second main result to emerge from our analysis is the observation that restricted choice within a PRA system improves the utility of most workers. To analyze choice, we use Social Security benefits as a benchmark against which to compare outcomes for PRA systems with different degrees of choice. We compare the utility of Social Security benefits to the expected utility across PRA outcomes for each worker for a given risk aversion parameter (γ) and conditional on a worker's lifetime earnings. For a risk aversion parameter of γ=3.8, taken from studies estimating risk aversion over income uncertainty, we find that 36.9% of workers prefer Social Security to PRAs without allocation or investment choice, but all workers prefer Social Security with both allocation and investment choice. While it may seem paradoxical that choice hurts workers, the reduction in utility arises because workers in our simulation may make suboptimal choices. With allocation choice, some workers choose stock allocations inconsistent with their risk preferences. With equity choice, some workers fail to diversify effectively. As discussed above, suboptimal portfolio selection is consistent with empirical studies of investor behavior.

Our utility calculations require the strong assumption that workers have time-additive constant relative risk aversion (CRRA) utility over retirement income. We supplement this analysis by estimating the probability that a worker's PRA income is less than her promised Social Security benefit (income shortfall)[4].

With regard to income shortfalls, we find that allowing investment choice materially increases the probability that a worker earns PRA income below her Social Security benefit. In our baseline simulation without allocation or equity choice, the risk that an individual worker experiences an income shortfall at age 88 is 26.6%. Allocation choice increases this risk to 30.8%, while equity choice increases it to 36.7%. With both allocation choice and equity choice, the probability of an income shortfall is 41.0%. Income shortfalls are material; conditional on an income shortfall, mean PRA retirement income is about half of the promised Social Security benefit.

We define a worker to be at risk of an income shortfall if her PRA income is less than her promised Social Security benefit in more than 25% of simulations and refer to the proportion of the worker population at risk according to this definition as "percent-at-risk." Without investment choice, the percent-at-risk at age 88 is 42.2%; allocation choice increases this risk to 52.4%, equity choice increases it to 74.6%, and allocation and equity choice increases it to 81.9%. With equity and allocation choice, more than 8 of 10 workers have greater than a 25% probability that age 88 PRA income falls short of promised Social Security benefits. The increase in shortfall risk with allocation choice results primarily from workers who allocate a relatively small percentage of their retirement accounts to equity. The

[4] We treat promised Social Security benefits as risk free. Luttmer and Samwick (2012) estimate that on average individuals would be willing to forego 4 – 6 percent of the benefits they are supposed to get under current law to remove the policy uncertainty. Adjusting promised Social Security benefits by 4 – 6 percent does not affect our two main results: (1) analyses based on a representative investor are misleading and (2) choice in PRA systems can reduce worker utility. Policy uncertainty reduces the expected utility of Social Security benefits, but does not affect the performance of PRA systems with and without choice nor their rankings relative to Social Security as a benchmark. While we could compare PRA systems directly to each other, simulating Social Security outcomes enables us to put differences in PRA performances in perspective and also to show that the representative worker benefits more from PRA systems than do most workers.

increase in shortfall risk with equity choice results from workers failing to effectively diversity their stock investments.

Market returns play a big role in the attractiveness of PRAs. However, investment choice leaves investors with a high probability of income shortfalls, even if they enjoy high market returns during their saving years. Each of our simulations can be thought of as a generation of workers who experience a different market outcome. We sort simulations into quintiles based on market outcomes during workers' saving years. For the top quintile of market outcomes, the 50/50 stock/bond index portfolio earns an impressive average return of 10.0% and the probability of an income shortfall for a worker is 5.9% at age 88 without choice. With allocation choice, the probability of a shortfall increases to 11.2%. Equity choice increases the shortfall risk to 15.5%, while both allocation and equity choice increase it to 20.6%. Decision risk has a large effect even in good market conditions. In the top quintile of market return outcomes, allowing both allocation and equity composition choice leads to about 3 in 10 workers facing greater than a 25% risk that PRA income falls short of promised Social Security benefits at age 88 (vs. 6 in 100 without choice).

Our analysis highlights the importance of two dimensions of choice in a PRA system. First, limiting equity options in a PRA system to well-diversified and low cost options is important to reduce the risk generated by equity choice. While at first blush this might seem like a simple policy solution to the decision risk that we document, the reality is not as obvious. As we discuss in detail later, in the Australian Superannuation Guarantee (PRA) system and the market for US 401(k) plans, investor choice was initially limited, but has expanded rapidly over time.[5] In Australia, the additional options resulted in widely different outcomes for investors. In US 401(k) plans, expanding options led to higher fees as new options were tilted toward more expensive actively managed funds (Brown, Liang and Weisbenner 2007). Second, ensuring investors have the appropriate tools to make well-informed asset allocation decisions is important.

We compare progressive Social Security benefits for which low-income workers earn higher benefits per dollar contributed than high-income workers to a non-progressive PRA system. Naturally, the PRA is less appealing to lower income than high-income workers.[6] When we sort on income quintiles, our analysis of utility over retirement income reveals that virtually all workers in the bottom two quintiles of lifetime earnings prefer Social Security to PRAs at moderate levels of risk aversion (γ=3.8). By contrast, all workers in the top quintile of lifetime earnings prefer PRAs to Social Security at moderate

[5] The Bush proposal for Social Security reform, summarized in the 2001 Report of the President's Commission on Strengthening Social Security and Creating Personal Wealth for Americans, offered two tiers of investment. Tier 1 was modeled after the federal government Thrift Savings Plan with limited investment choice, but Tier 2 afforded more choice in an effort to provide competition and choice among fund providers.

[6] See Samwick, 2009, for a discussion of how progressivity could be incorporated into a PRA system.

levels of risk aversion (γ=3.8). However, virtually all workers (both rich and poor) prefer Social Security to PRAs with both allocation and investment choice. Thus choice dramatically reduces the appeal of PRAs even to the highest income workers.

In summary, our simulation-based analysis yields two main insights. First, the outcomes of a representative worker should not be used to assess population wide benefits of private-account alternatives, because, as we show, a representative worker who earns his cohort's average annual salary benefits much more (and with greater certainty) from a private-account alternative than do most workers. Second, investment choice decreases worker utility in a PRA system. Over reasonable levels of risk aversion, allowing either allocation or equity choice leaves most workers preferring Social Security. Allowing allocation choice in PRAs increases the probability of an income shortfall relative to Social Security benefits, as some workers will allocate a relatively small amount of their investment portfolio to stocks. Allowing equity choice increases the probability of an income shortfall relative to Social Security benefits, as some workers will fail to effectively diversify.

Though we study outcomes of PRA systems as alternatives to Social Security, our results regarding equity and allocation choice generalize to self-directed retirement accounts intended to provide for the basic living needs in retirement. With greater allocation choice and greater equity choice, more workers are likely to fall short of their minimum goals than if they invest in a balanced portfolio of equity and bond index funds.

After presenting our results, we argue several features of our simulation-based evidence underestimate the effect of choice on workers' retirement outcomes. For example, our simulations prohibit bequests of PRAs, require the purchase of indexed variable annuities in retirement, assume investment expenses are less than those currently charged by mutual funds, and assume all investors have the same ability to pick stocks and mutual funds.

I. Institutional Background and Related Literature

I.A. Our Benchmark: The Current Social Security Program

Social Security provides guaranteed retirement benefits to those who contribute to the system during their working years. While the majority of Social Security benefits go to retirees, the disabled and family members of beneficiaries also receive benefits. The system is often referred to as a defined-benefit pay-as-you-go (PayGo) system as current taxes are used to pay benefits to current retirees. The Social Security program was adopted as a response to the Great Depression, with the first benefits being paid in 1940.

Social Security was intended as insurance against "…poverty-ridden old age," to borrow the words of President Roosevelt. Poverty for those over age 65 declined dramatically from about 30% in 1966 to 9% in 2011, with many identifying Social Security benefits as a major factor in the decline

(Brady, Burham, and Holden (2012), Figure 6, p.14).[7] In keeping with the goal of reducing post-retirement poverty, Social Security benefits are higher (as a proportion of contributions) for lower-income workers. As we discuss in detail later in the paper, the current benefit formula is based on three income tiers, which results in two bend points. The maximum monthly social security benefit is $2,642 for someone who retires at age 66 in 2014.

In 2014, the Social Security tax is 12.4% (a temporary reduction to 10.4% was enacted as part of the Tax Relief Act of 2010, which was extended through 2012). Until recently, Social Security tax receipts have exceeded benefits with the surplus credited to the Social Security Trust Fund. According to the 2014 Board of Trustees Report (p.3), a combination of the Trust Fund and tax receipts will be sufficient to pay Social Security benefits, as currently promised, until 2033. Proposals to address this funding shortfall include increasing the retirement age, indexing wages upon which benefits are based to CPI instead of wage inflation, and increasing either the tax rate or amount of earnings subject to tax (the income ceiling). Administrative projections suggest that to remain solvent for the next 75 years, the Social Security tax would need to immediately increase from 12.4% to 15.23%, (Board of Trustees 2014, p.4).

The Social Security funding shortfall is the result of Social Security being set up as an unfunded pay-as-you-go system that delivered about $14 trillion of net transfers (in 2014 present value dollars) to people born before 1937. (See Geanakoplos, Mitchell, and Zeldes (1999) for an in depth discussion of the implications of this unfunded liability for returns in a privatized system.) If Social Security were privatized, taxes would need to be levied to pay this liability. We ignore Social Securities' projected shortfall as well as the analogous costs of paying this unfunded liability in a transition to a PRA system.

We treat both our Social Security benchmark and the PRA plans as self-funding for the cohort we study. We make Social Security self-funding by setting the Social Security tax rate to 8.8%. In our simulations, the 8.8% tax rate is sufficient to guarantee the aggregate cohort Social Security payout assuming the savings earn the equivalent of US five-year government bond rates.

I.B. Private Retirement Accounts (PRAs)

Private retirement accounts (PRAs) have been proposed as alternatives to Social Security. These proposals do not address the funding shortfalls discussed above. Instead, they emphasize individual ownership and responsibility, and allow individuals to choose how retirement assets are invested.

In his 2004 State of the Union address, President Bush made the case for PRAs: "Younger workers should have the opportunity to build a nest egg by saving part of their social security taxes in a personal retirement account. We should make the Social Security System a source of ownership for the

[7] During the same period, poverty rates among those aged 18 to 64 increased from about 10% to 14%.

American people." Though proposals vary in their details (see Murphy and Welch 1998 for a summary of several proposals), individuals would generally have ownership of their retirement accounts and, potentially, broad discretion over how they are managed.

While many privatization reform plans initially restrict investment choice, restrictions often give way to more choice over time. For example, Australia legislation to adopt a PRA (the Superannuation Guarantee) was passed in 1992. When first introduced, employees had very limited choices available (Fear and Pace 2009). Over time, the choices available to employees have expanded, an expansion accelerated by the passage of the Superannuation Legislation Amendment (Choice of Fund) Act in 2004. Workers invest through a superannuation fund, often referred to as a super fund. In 2011, there were hundreds of super funds. Each super fund may offer workers a wide variety of investment options (one fund offered 2,700). The investment options offered by a super fund have few restrictions and can include mutual funds, individual stocks, hedge funds, private equity, and property trusts (to name a few).

The experience in 401(k) retirement plans in the US is also informative. Brown, Liang, and Weisbenner (2007) document the number of options available to workers has increased over time. In addition, the new options tend to be actively managed equity funds that charge higher fees and earn lower returns. More recently, brokerage windows, which allow investors to direct 401(k) assets to brokerage accounts and purchase individual equities, have become increasingly popular. Aon Hewitt (2013) reports the percentage of plans that offer brokerage windows has increased from 12% in 2001 to 40% in 2013.

Some have argued for expanding choice in the current reform models. Michael Tanner, Director of the Cato Institute Project on Social Security Privatization, testified before President Bush's commission on Social Security reform and argued in favor of broad investment choice, suggesting individuals "…should be given as wide a range of investment opportunities as possible, consistent with regulatory safeguards against fraud or speculation. While investing in 'Singapore derivatives' or your brother-in-law's South American gold mining stock is clearly not envisioned, there is no reason to limit workers to two or three index funds."[8]

The anticipated benefits of personal accounts include direct ownership (including heritability) and higher expected returns from investing in equities and other securities. Several studies (for example, Diamond and Geanakopolos 2003; Modigliani, Ceprini, and Muralidhar 2003) point out the returns and risks from investing in equities could be incorporated into Social Security without adding to the administrative costs of managing many individual personal accounts.

Several prior studies have analyzed the outcomes we might expect from a PRA system. However, we add more detailed assumptions regarding risks and expected returns faced by workers in their forced

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[8] Testimony of Michael D. Tanner Director, before the President's Commission to Strengthen Social Security, October 18, 2001, http://www.ssa.gov/history/reports/pcsss/Tanner_Testimony.pdf.

savings accounts. For example, the Bush Commission's projections assume that all personal accounts are invested in a 50/50 portfolio of equities and bonds that earn a constant annual real rate of return of 4.6%; a constant return assumption is clearly unrealistic when workers invest in risky assets (particularly stocks).

Feldstein and Liebman (2002) consider the distributional aspects of Social Security by considering worker-level outcomes, but do not model variation in market outcomes or risks arising from workers' different investment choices. They conclude that virtually all demographic groups benefit from a shift to PRAs. Feldstein and Liebman (2002) assume a constant (i.e., risk-free) annual after cost logarithmic real portfolio return of 5.5% on PRA investments, which is close to the historic returns on a 60/40 stock/bond portfolio. However, they do not model variation in the returns earned on these risky investments across years or across households.

Feldstein and Ranguelova (2001) analyze outcomes of a representative worker who invests in a PRA and conclude the representative worker generally fares well under PRAs. They assume that personal accounts are invested in a 60/40 portfolio of equities and bonds, which earns a stochastic annual real return of 6.5%.[9] The returns earned in personal accounts vary across cohorts, but *not* across individuals within a cohort. Variation in outcomes across cohorts captures the risk that a particular generation of workers will experience a poor investment outcome. Gollier (2008) and Shiller (2006) also study this generational risk. We extend this line of inquiry by allowing for variation in returns across cohorts and, more importantly, allowing variation in investment choice across individuals within a cohort.

Our first departure from prior studies is to consider worker-level outcomes in a setting with stochastic investment returns. Next we allow for allocation choice in an investor's PRA. None of the aforementioned models studies the impact of allocation choice—the mix of stocks and bonds chosen by each individual in their investment portfolio. This is an important dimension of choice that almost certainly has a big impact on expected outcomes for workers. Extant research indicates that the stock-bond allocation decisions of investors are largely idiosyncratic. For example, Shum and Faig (2006) analyze the SCF data and conclude that less than 10% of the variation in stock ownership can be explained by 18 variables conjectured to predict variation in stock ownership (e.g., education and age). Consistent with the observation that the stock allocation choices of investors are largely idiosyncratic, the stock allocation choices of investors are heavily influenced by the default options (e.g., Beshears, Choi, Laibson, and Madrian 2008, 2009) and choice framing (Benartzi and Thaler 2001, 2007). In addition,

[9] Feldstein and Ranguelova (2001) assume a mean annual real log return of 5.5% on a 60/40 stock/bond portfolio (with a standard deviation of 12.5%), which corresponds to a mean level return of approximately $6.5\% = e^{\left(5.5\% + \frac{(125)^2}{2}\right)} - 1$. Our main results differ from theirs because they ignore worker-level outcomes focusing only on a representative worker and, we believe, they overestimate the market risk premium by using historical averages.

many investors fail to participate in stock markets or allocate only a small fraction of their financial assets to equities (Campbell 2006).

Our second innovation is to consider cross-sectional variation in the equity returns of individual workers. Even when investors experience the same market return, their personal investment results will vary. Modeling this cross-sectional variation in performance is important, as some investors will beat the market while others will underperform. There is considerable evidence that individual investors do not manage equity portfolios optimally. Investors fail to diversify their retirement portfolios by, for example, overinvesting in their employer's stock (Poterba 2003; Benartzi 2001). Kelly (1995), analyzing data from the U.S. Survey of Consumer Finances, and Goetzmann and Kumar (2008), analyzing data for a large U.S. broker, conclude investors fail to diversify their stock portfolios. Benartzi and Thaler (2001, 2007) argue investors follow naïve diversification strategies in their retirement plans. Calvet, Campbell, and Sodini (2009) analyze complete portfolios for Swedish households. While the median household holds a well-diversified portfolio, some households hold portfolios that are severely underdiversified. In addition, households with low education and wealth are less likely to participate in the stock market and more likely to invest inefficiently if they do participate. Gaudeker (2015) analyzes the complete portfolios of Dutch investors and finds the underdiversificaiton is more prevalent among investors with low levels of financial literacy who self-manage their investment portfolios. Similarly, Grinblatt, Keloharju, and Linnainmaa (2011) and Grinblatt, Ikäheimo, Keloharju, and Linnainmaa (2012) show that cognitive abilities positively affect both stock market participation and trading performance among Finnish investors. In summary, there are many reasons to believe there will be high cross-sectional variation in investor outcomes under a PRA system, particularly since many workers tasked with managing their retirement portfolios will be new to investing and thus lack investment experience or knowledge.

By modeling outcomes at the individual rather than cohort level, we are also able to identify demographic patterns that emerge when we shift from an insurance-based Social Security program to PRAs. Under the current Social Security scheme, those who earn low wages during their lifetime receive proportionately greater benefits than high-wage earners. Thus, a worker-level analysis allows us to estimate the probability of an income shortfall for different demographic groups, which is clearly important given the progressive nature of Social Security benefits.

Finally, modeling outcomes at the individual rather than cohort level also allows us to compare the outcomes of individual workers to that of a representative worker. Compared to a representative worker, individual workers face greater lifetime income uncertainty, work for fewer years, and have lower (median) incomes. Thus the welfare implications of switching from Social Security to PRAs for a representative worker are not a good measure of how such a switch affects the welfare of most workers.

II. Data and Methodology

In our base case, we compare PRA income, where workers without investment choice invest in a 50/50 stock/bond portfolio and purchase a variable annuity in retirement, to currently promised Social Security benefits based on a worker's earnings history. We simulate the experiences for 10,000 generations of workers. Each generation shares the same income profile, but experiences a different market return.

We use simulated data for lifetime earnings of a cohort of 3,655 individuals born in 1979, which we obtained from CORSIM. CORSIM provides a detailed micro-simulation of incomes for a representative sample of the US population based on numerous sources (e.g., Survey of Consumer Finances, Panel Study of Income Dynamics, and The US Census). See Caldwell (1996) and Caldwell and Morrison (2000) for details. The CORSIM micro-simulations have been used in studies by Caldwell et al. (1999) and Gokhale and Kotlikoff (1999, 2002). The data include demographic details (e.g., race and gender), annual earnings subject to social security benefits, and year of death.

In the online appendix, we present descriptive statistics on lifetime earnings of the 1979 birth cohort by decade from 1999 through 2069. Mean and median income increase with age until the cohort reaches age 50 and then tails off quickly as workers retire. In Figure 1, we plot the percentage of the cohort still living by age for the CORSIM data, which are quite similar to projections from the Social Security administration.

II.A. Estimating Social Security Benefits

We estimate the currently promised Social Security benefit for each worker in each year during retirement based on the algorithm used to calculate Social Security benefits as described in Board of Trustees (2013) and assuming a retirement age of 67.[10] The current algorithm used by Social Security establishes a benefit level for each worker at retirement. Once a benefit level has been established, it increases each year based on cost of living adjustments. The Social Security Act specifies that several parameters, which affect benefit levels, be set annually based on changes in economic conditions. Key parameters include the index factor for wages, the increase to the highest wage level eligible for benefits, and the increase in benefits to account for inflation. In the online appendix, we describe these calculations in detail.

II.B. Private Retirement Account (PRA) Income

To calculate PRA income, we assume workers are required to save the equivalent of their Social Security tax in a defined-contribution PRA. In our base case, we assume workers invest their PRAs in

[10] The normal Social Security retirement age varies from 65 for those born in 1937 and earlier to 67 for those born in 1960 or later.

portfolios with a 50% allocation to equities and 50% allocation to bonds with annual rebalancing. Simulated returns on 50/50 portfolios average 7.6% per year. In retirement, we assume all workers buy a variable annuity. Thus, mortality risk is pooled, but each worker continues to bear market risk in retirement. We assume any balances in the PRAs of those who die before retirement are transferred to a common pool that continues to earn returns until the cohort retires and is then used to help finance the cohort's variable annuity.

B. 1. Savings Rate

Our simulations assume a savings rate (or, equivalently, Social Security tax) of 8.8%. We arrive at this savings rate by assuming the aggregate savings of a cohort are sufficient to fund its retirement obligations if the cohort savings earned a rate of return equal to that on long-term US government bonds. We believe this is a reasonable assumption, since these obligations are virtually default free and are a close approximation to the type of security that would be used to immunize the liability generated by the cohort's retirement obligations. Specifically, we assume that the real log return on long-term government bonds is 1.79%, the mean real log return on long-term government bonds from 1946-2013. We adjust the assumed real return on long-term government bonds to reflect an assumed inflation rate of 3% (log inflation of 2.96%), yielding a nominal mean log return of 4.75%. Given this return assumption, we calculate the savings rate (or Social Security tax) that would fund the cohort's retirement obligations to be 8.8%.[11]

B. 2. Portfolio Returns without Choice

We assume the annual return on a 50/50 stock/bond portfolio is 7.6% per annum. We assume that stocks earn a mean annual level return of 9.5%, bonds earn 5.7%, and the inflation rate is 3%. Assuming one-month Treasury Bills earn 50 bps over inflation,[12] we implicitly assume an equity risk premium v. T-Bills of 6.0% = 9.5% - 3.5%.

In this section, we discuss the reasoning behind these assumptions. To calibrate our return assumptions, we begin with data from Ibbotson Associates for the postwar period 1946 to 2013. Our equity returns are based on the S&P 500 Index (Ibbotson's large company stock index) and corporate bond returns are based on the Ibbotson long-term corporate bond series. Real log returns are calculated by deducting (CPI) log inflation in each year. The mean and standard deviation of the log real returns on

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[11] The assumed savings rate (or Social Security tax) of 8.8% is 71% of the current OASDI tax rate of 12.4%. Our simulation of a solvent Social Security system requires lower taxes than the current 12.4% for two reasons. First, the current tax rate is required to partially fund the large embedded liability in the PayGO system that results from the transfer to retirees born prior to 1937. Second, the 12.4% tax rate funds both old age supplements (OAS) and disability income (DI). Our simulations only consider OAS payments, which represent about 2/3rds of total Social Security payouts.

[12] From 1926 to 2013, the annual level return on T-bills was 3.54% and CPI was 3.04%.

equity are 6.6% and 17.4%, while the corresponding values for long-term corporate bonds are 2.1% and 9.7%. The covariance between the two series is 0.0042, yielding a correlation between stock and bond returns of 25%. We adjust the real returns on stocks and bonds to reflect an assumed inflation rate of 3% yielding nominal mean log returns on stocks and bonds of 9.6% and 5.1%, respectively.[13]

We shave the assumed log return on stocks by two percentage points, from 9.6% to 7.6%, which is equivalent to shaving the level return on stocks from 11.8% to 9.5%. We do so for two reasons. First, there is a general consensus that realized returns in the 20th century represent an equity premium puzzle (Mehra and Prescott 1985). As a result, several scholars argue in favor of an expected equity premium well below historic averages. Fama and French (2002, p.657) argue dividend and earnings growth models yield an equity risk premium estimates that are closer to the true expected value; in the 1951-2000 sample period, the dividend and earnings growth model yield estimates of the equity risk premium that are 3.1 to 4.9 percentage points *less* than the historical equity return, which suggests our assumption of a mean equity return 2 percentage points below its historical average may be conservative. Our assumptions regarding stock returns yield a healthy equity risk premium v. long-term corporate bonds of 3.8% = 9.5% - 5.7%. Given the default risk of corporate bonds, the equity risk premium v. long-term government bonds would be greater than 3.8%, which is still above many equity risk premium estimates. For example, Arnott and Bernstein (2002, pp.80-81) argue "…[the] observed real stock returns and the excess return for stocks relative to bonds in the past 75 years have been extraordinary… The historical average equity risk premium, measured relative to 10-year government bonds as the risk premium investors might objectively have expected on their equity investments, is about 2.4 percent…" Siegel (2005, p.70) reviews evidence on the equity risk premium and reaches a similar conclusion: "…there are good reasons why the future equity risk premium should be lower than it has been historically, projected compound equity returns of 2-3 percent over bonds will still give ample reward for investors willing to tolerate the short-term risks of stocks." Diamond (2000) reaches a similar conclusion, suggesting realistic GDP growth estimates are consistent with long-term stock returns considerably lower than 7%.

Second, the lower stock return yields a level portfolio return in our simulations of 7.6%, which is within the 7.3% to 8.5% range of expected returns used by U.S. state pension funds in 2005 (Novy-Marx and Rauh 2008). Aon Hewitt Associates (2014) conducts surveys of clients who manage defined-benefit plans and reports the average forecast of long-term returns for US providers to be 7.1% in 2013.

In our simulations, we draw stock and bond log returns from a bivariate normal distribution with means of 7.6% and 5.1%, standard deviations of 17.4% and 9.7%, and a correlation of 25%. The simulated log returns are converted to level returns to calculate the level return on a 50/50 stock/bond

[13] During the 1946 to 2008 period, CPI inflation averaged 4.03%, and the nominal mean log return on stocks and bonds were 9.9% and 5.8%, respectively.

portfolio. From the portfolio return, we deduct a portfolio administration expense of 0.40% annually. Whether this is high or low depends on the nature of the choices available in PRAs. For example, if investors choose from the universe of mutual funds currently offered, the 0.40% would be low. The asset-weighted expense ratio for equity mutual funds is 1.11%, while that for bonds is 0.78% (Khorana, Servaes, and Tufano 2009). These expenses would likely be higher if workers were allowed to trade individual stocks as commissions and spreads would erode returns (Barber and Odean 2000).

B. 3. Portfolio Returns with Choice

a) Stock-Bond Allocation Choice

Most individually controlled retirement account plans (e.g., 401(k)s, Keoghs, IRAs) as well as the alternative PRA proposals in the 2001 Report of the President's Commission on Strengthening Social Security and Creating Personal Wealth for Americans allow investors to choose their stock-bond allocation. To assess the impact of allocation choice on outcomes, we consider simulation with and without allocation choice. In our baseline simulations, we assume all investors choose a 50/50 stock/bond allocation. In our allocation choice simulations, we model variation in choice using the observed stock allocation in retirement accounts[14].

To estimate the variation in stock allocation in retirement accounts, we use the 2010 Survey of Consumer Finance (SCF) dataset. For each household in the dataset, we sum investments in IRAs, Keoghs, and 401k plans. For those households with a positive balance in at least one of these retirement accounts, we calculate the percentage of the account allocated to stock. Since we are focused on allocations during workers savings years, we restrict the analysis to households under the age of 68. For households with positive balances in retirement accounts and a head of household under the age of 68, the average (median) balance in these retirement accounts is $145,000 ($38,000), and the average (median) household allocates 48% (46%) of the account investments to stock. To reduce the complexity of our simulations, we do not model allocations to stock as a declining function of age, but note the cross-sectional variation in allocation choices is much greater than the variation in average allocation by age group.[15]

In Figure 2, we present the percentiles of stock allocation for these households. About 12% of households have no allocation to stocks and about 14% of households allocate 100% of their investments

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[14] Binsbergen, Broeders, de Jong, and Koijen (2013), Bovenberg, Mehlkopf and Nijman (2014), Berkelaar, Kouwenberg, and Post (2004), and Dahlquist, Setty and Vestman (2014) explore optimal portfolio choice in defined contribution pensions.

[15] The average equity allocation ranges from 43% for those in their 60s to 52% for those in their 20s. The mean and median household allocation to equity in tax-deferred retirement accounts were close to 50% in the 2004 and 2007 SCF datasets.

to stock.[16] In our simulations that allow allocation choice, for each worker, we sample from a uniform distribution from 0 to 100, round to the nearest integer, and identify the stock allocation for the corresponding percentile from Figure 2. This stock allocation is then used as the stock-bond allocation for the worker during all of his saving years.

We model the allocation choice in this way for two reasons. First, we do not know workers risk preferences so we implicitly assume the risk appetites are randomly assigned. Second, investors' allocation choices in defined contribution retirement accounts (e.g., contribution rates, asset allocation decisions, and investment in own company stock) are influenced by plan default options (e.g., Beshears, Choi, Laibson, and Madrian 2008, 2009) and choice framing (Benartzi and Thaler 2001, 2007). This suggests that at least some investors' observed choices are not determined based on solving a portfolio optimization problem. Alternatively, we could model allocation choice as a function of demographic characteristics. For example, stock market participation tends to be lower for the less wealthy, so we might assume that low-income workers are more likely to spurn equity investment in their retirement accounts. However, lower income workers may also be more likely to choose default options, which could result in higher equity investments and less active trading.

Stock and bond allocation decisions reported in the SCF are made by households who anticipate receiving Social Security benefits—a low-risk cost-of-living protected annuity. If households are currently optimizing their asset allocation, then in the absence of Social Security they will reduce their allocation to stocks and increase their allocation to bonds (or annuities). As we document later, a lower equity allocation tends to increase the probability of an income shortfall; thus, lower equity allocations for any reason would further increase the probability of an income shortfalls.

b) Stock Investment Choice

When investors have choices other than index funds, individual investment outcomes will vary from market returns. To calibrate the extent of this variation, we use realized returns in tax-deferred retirement accounts at a large discount broker in the US over the period 1991 to 1996. The dataset contains records for 78,000 households, but we limit our analysis to households' equity investments in tax-deferred retirement accounts for which we have complete positions during a calendar year (so we can reliably estimate the annual return earned in a household's tax-deferred account). Thus, the sample size ranges from about 16,000 households in 1991 to 24,000 in 1996. The mean (median) investment in a tax-

[16] Social Security is a large part of the retirement portfolio for many of these households and is effectively a fixed income investment converted to an annuity upon retirement. Thus the SCF Survey underestimates how conservatively total household retirement savings (including Social Security) are actually invested.

deferred account is $33,000 ($15,000) across household years.[17] (See Barber and Odean (2000) for a complete description of these data.) These households invest in a combination of individual stocks and mutual funds. For the average household, the tax-deferred account represents 79% of their total equity investments at the broker and 36% of the tax-deferred account is held in mutual funds with the remainder in individual stocks. For each household, we calculate the monthly portfolio return by matching month-end positions to Center for Research in Security Prices (CRSP) data on stock and equity mutual fund returns. From these monthly returns, we calculate an annual return for each household. These annual returns are used to calibrate the variation in annual returns across households.

In the online appendix, we present the mean level and log return across households and the cross-sectional standard deviation of returns. Across the six-year sample period, the average annual return earned by households is 18.1% (before deducting transactions costs), slightly less than the average return on the S&P 500 (18.4%) and the CRSP value-weighted market index (18.9%) over the same period. The cross-sectional standard deviation in log returns averages 24% across the six-year sample period.

To model this cross-sectional variation in returns, we assume the cross-sectional distribution of household log returns is normally distributed with a standard deviation equal to 24% (i.e., the annual standard deviation of the household log returns). Thus, household log returns exhibit two sources of variation: time-series variation in equity market returns (18.6% from above) and cross-sectional variation in household returns (24%). We assume these two sources of variation are normally distributed and independent. Thus, combining variation in equity market returns and the cross-sectional variation in household returns, the time-series standard deviation of the household log return is $29.6\% = \sqrt{.174^2 + .240^2}$.

In our choice-based simulations, we assume all investors invest in a 50/50 stock bond portfolio with annual rebalancing and bond returns do not vary across investors. However, each investor earns a different return on his or her stock portfolio, though investors collectively earn the simulated market return. To simulate this cross-sectional variation, we proceed in two steps. First, in each simulated year we draw a market return for equity, which is common for all investors. Second, we add idiosyncratic volatility to each investor's annual stock market return. Some investors beat the market, while others underperform.[18]

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[17] Though we estimate equity return variation in actual retirement accounts, many of these accounts (e.g., IRAs) will not have default options. We would expect less variation in equity returns in a PRA system with well-diversified equity defaults.

[18] The choice-based simulations assume the same annual level return on stocks (9.5%) as the no-choice simulations. To do so, we draw a log market return from a normal distribution with a mean of 4.7% and a standard deviation of 17.4%. Idiosyncratic volatility is added by drawing from a normal distribution with mean zero and standard deviation of 24.0%. The two draws are added to yield the household's log equity return for the year, which is normally distributed with a mean of 4.7% and a standard deviation of 29.6%. Thus, we preserve the assumed level

We assume the variation in outcomes across households is random within and across years. We do so for modeling simplicity, but this likely underestimates the effect of equity choice on the variation in outcomes that would be observed in a PRA system since a household that is undiversified in one year is likely to remain undiversified in subsequent years.

B. 4. The Variable Annuity

We assume cohort members begin work at the beginning of their 21st year and retire at the end of their 67th year. The aggregate value of the cohorts' PRAs at retirement is used to finance a variable annuity for the cohort. Denote the aggregate value of assets of the cohort up to age 68 as V_{68}, the aggregate annuity payment at age 68 (the first year of retirement) as A_{68}, the expected return of the portfolio as R, the inflation rate i, and the expected number of cohort members alive at age t as N_t based on actual mortality in the CORSIM dataset. Then, $A_{68} = V_{68} / APV_{68}$, where

$$APV_{68} = \sum_{t=68}^{100} \frac{N_t}{N_{68}} \left(\frac{1+i}{1+R}\right)^{(t-68)} \quad (1)$$

represents the actuarial present value (APV) of an expected \$1 real annual payment for the rest of an individual's life. In subsequent years, the aggregate annuity payment changes as realized returns will differ from expected returns. Because realized returns differ from expected returns, PRAs generate volatile retirement income. In years with strong market returns, the income from the PRA will increase, while in years with poor market returns, the income will decrease.

Each cohort member who retires receives a portion of the aggregate annuity payout, where the portion is the ratio of the retiree's PRA value to the total value of all currently living retirees' PRAs, where all PRA values are measured at retirement. Those who die before retirement contribute to the aggregate cohort pool V_{68}, but do not receive a portion of the cohort's variable annuity. Thus, the denominator used to calculate each retiree's portion of the cohort annuity excludes the value of the PRAs for those who die prior to retirement. We use the mortality tables implied in CORSIM data, but assume all cohort members still alive at age 99 all die at age 100 (see Figure 1). We present an example of the cohort annuity calculation in the online appendix.

III. Results

We estimate the percentage of the population that prefers Social Security to PRAs (with different levels of choice) based on a lifetime utility calculation, where we vary the level of relative risk aversion used in the calculation. Specifically, we calculate lifetime utility, *E[u],* for each worker assuming a constant relative risk aversion (CRRA) utility function, *u(Ct)*:

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return on equity (9.5%) by shaving the log return on equity from 7.6% to 4.7%: 9.5% = exp(.076+.5*.174^2)-1 = exp(.047+.5*.296^2)-1.

$$u(C_t) = \frac{{C_t}^{1-\gamma} - 1}{1-\gamma} \quad (2)$$

$$E[u] = E\left[\sum_{t=68}^{100} \beta^{t-68} u(C_t)\right] \quad (3)$$

where γ is the worker's relative risk aversion parameter, and *β* is his time discount factor. We assume a discount factor *β*=0.96. In the Social Security regime, C_t is the promised Social Security benefit; the expected utility under Social Security is equal to the utility of the promised Social Security benefits. In the PRA regime, C_t is the income from a variable annuity that is purchased at retirement using accumulated savings and investment returns during working years. For each worker, the expected utility under the PRA regime is equal to his average utility across the 10,000 simulations. At different levels of relative risk-aversion (γ), we count the number of workers who prefer Social Security to PRAs.

We next calculate the probability that a worker's PRA income is less than her Social Security benefit, which we refer to as an income shortfall, at the ages of 68, 78, and 88. We measure the probability of income shortfalls in two ways. First, we calculate the probability of an income shortfall across all workers and all simulations. We refer to this metric as worker outcomes. Second, we report the percentage of workers who experience income shortfalls in more than 25% of simulations. While the 25% cutoff is somewhat arbitrary, this measure emphasizes the safety-net nature of Social Security for many workers and the asymmetrical effect on utility of losses versus gains relative to promised payments. This metric measures the percentage of workers with a risk of more than one quarter of being worse off with a PRA. We refer to this metric as percent-at-risk. Both of these measures focus on the downside risk of PRAs relative to Social Security, which we believe appropriate given its social insurance objective.

III.A. Expected Utility

To consider whether the potential upside associated with private retirement accounts with varying degrees of choice is sufficient to compensate for downside risk, we analyze the percentage of the population that prefers Social Security to different PRAs given each member of the population has CRRA utility with a specified level of relative risk aversion (γ). To estimate how risk averse people are, economists analyze a wide variety of data including investment returns, options pricing, insurance choices, insurance deductibles, peer-to-peer lending, and survey responses; estimates of CRRA risk aversion levels vary from less than 1 to more than 50.[19] Rabin (2000) shows that within an expected utility framework typical choices for small and moderate stakes gambles imply absurdly high levels of risk aversion for gambles over large stakes. Rabin and Thaler (2001) write "… the correct conclusion for

[19] E.g., Friedman (1973), Friend and Blume (1975), Hansen and Singleton (1982), Mehra and Prescott (1985), Szpiro (1986), Campbell (1996), Ait-Sahalia and Lo (2000), Bliss and Panigirtzoglou (2004), Sydnor (1010), Chiappori and Paiella (2011), and Paravisini, Rappoport, and Ravina (2013).

economists to draw, both from thought experiments and actual data, is that people do not display a consistent coefficient of relative risk aversion…"

To the extent possible, risk aversion should be measured in the context of the choices being considered. Since Social Security benefits provide income in retirement, the most relevant consideration is the distribution of retirement-income-based risk aversion in the population. Barsky et al. (1997) elicit relative risk aversion parameters by asking subjects a series of questions about their willingness to take a risky new job. For example, subjects who reject the opportunity to take a new job with a 50-50 chance it will double their income and a 50-50 chance that it will cut their income by 20% have an implied risk aversion parameter greater than 3.76. Based on these questions, Barksy et al. (1997) find that 65% of subjects make choices consistent with an income-based risk aversion parameter greater than 3.76 (i.e., reject the new job with a 50-50 chance of doubling income or cutting it by 20%). Hanna, Gutter, and Fan (2001) document that risk aversion is greater when these questions are modified to ask about a pension in retirement rather than income from a new job and the median response is 5.65. Because the estimates from these studies map closely into the setting we analyze, we calculate results for relative risk aversion parameters of 3.8 and 5.65[20]; to illustrate the sensitivity of the analysis to risk aversion assumptions we also include results for a relative risk aversion parameter of 2.0.

The results of this analysis are in Table 1, where we report the percentage of the population that prefers Social Security to PRAs across 10,000 simulations. We present four sets of results, where we alternatively consider outcomes with/without allocation choice and with/without stock investment choice. In each panel of this table and those that follow, we present results in the following matrix format:

No Stock Investment Choice 50/50 Stock/Bond Allocation	With Stock Investment Choice 50/50 Stock/Bond Allocation
No Stock Investment Choice Stock/Bond Allocation Choice	With Stock Investment Choice Stock/Bond Allocation Choice

In Panel A, we present results for all workers. Assuming each member of the population has a relative risk aversion of 2.0, 20.3% of workers prefer Social Security to PRAs without choice but a much larger percentage (55.2%) prefer Social Security to PRAs with both equity and allocation choice (with most of the action coming from equity choice). When we use a relative risk aversion parameter of 3.8 (from Barsky et al. (1997)), 36.9% prefer Social Security without choice to a PRA, but nearly everyone (98.2%) prefers Social Security to a PRA with both equity and allocation choice. Finally, assuming a risk aversion parameter of 5.65 (the median from Hanna, Gutter, and Fan (2001)), 60.5% prefer Social

[20] Since 1992, the Survey of Consumer Finances asks the question "Which of the statements on this page comes closest to the amount of financial risk that you are willing to take when you save or make investments?" Between 1992 and 2001, the percentage of people choosing "Not willing to take any financial risks," ranged from 38.7 to 49.8 (Yao, Hanna, and Lindamood (2004)).

Security to a PRA without choice and everyone (100.0%) prefers Social Security to a PRA with both equity and allocation choice. In summary, regardless of the relative risk aversion parameter that we assume, choice leaves a majority of the population preferring Social Security to PRAs. Moreover, under realistic assumptions regarding the relative risk aversion parameter for retirement income decisions nearly everyone prefers Social Security to PRAs. In Panel B, we present results partitioned by lifetime earnings quintiles. Without choice, lower income households have a stronger preference for Social Security because of the progressive nature of Social Security benefits. However, for each income quintile, choice materially increases the proportion of the population favoring Social Security over PRAs.

Equity choice reduces utility because some investors fail to effectively diversify. Allocation choice reduces utility because some investors make allocation choices inconsistent with their risk aversion over retirement income.

In a model of utility-maximizing agents, relaxing a constraint will not make people worse off. We estimate variation in stock-bond allocation from the 2010 Survey of Consumer Finance and the variation in investment outcomes from tax-deferred retirement accounts at a large U.S. discount brokerage. We then assume that all workers in our simulation have the same level of risk-aversion (for three levels of risk-aversion) but make heterogeneous choices. Thus we are assuming that, given choice, people do not optimally maximize their expected utility. An alternative view would be that the variation in asset allocation documented in the Survey of Consumer Finances and the variation in investment choices at the large U.S. brokerage are rational responses to variations in personal beliefs and risk aversion and that, in practice, people always hold the portfolios that maximize their personal expected utility.[21] A great deal of empirical evidence suggests otherwise. For asset allocation, mutual funds selection, and individual equities trades, people make choices that are materially influenced by irrelevant information and that unnecessarily reduce their investment returns. For example, Benartzi and Thaler (2001) find that equity-bond asset allocation in 401(k) plans tends to match the proportion of equity and bond funds offered in each plan. If 70% (30%) of the funds offered in a plan are equities, workers invest about 70% (30%) of their 401(k) savings in equities. Benartzi and Thaler (2001) find no compelling economic reasons for workers' allocation choices to depend upon the proportions of equity and bond funds offered in their plan. In an experiment with substantial incentives, Laibson, Choi, and Madrian (2010) find that people choose S&P 500 index funds with higher historical performance and higher fees over S&P 500 index funds with lower historical performance and lower fees, even though the optimal choice is the low fee funds. Finally,

[21] Even if some workers did maximize their expected utility with very risky PRA portfolios, their risk-taking could impose undesirable externalities. Some workers who lost their PRA savings through risky investments would either go hungry and homeless in retirement or become burdens on society.

several studies document that equity trading by individual investors lowers average net returns (e.g., Barber and Odean 2000, Barber, Lee, Liu, and Odean, 2009).

One objection to Social Security when compared to a PRA system with allocation choice, is that workers are forced to invest in a low risk, low return asset, i.e., Social Security, regardless of their risk preferences. As discussed in Geanakoplos, Mitchell, and Zeldes (1998), this constraint is only binding on workers without investable savings outside of Social Security. A worker with additional savings can adjust his overall risk exposure by overweighting equities in his investments outside of Social Security. Similarly, workers with additional savings who felt constrained by a PRA system without choice could adjust their overall risk exposure with investments outside of the PRA.

III.B. Utility of the Representative Worker and Worker at Birth

In our expected utility calculations, investment returns are uncertain but income paths are fixed. Thus we are calculating expected utility of consumption in retirement from the perspective of a person who has not yet started working but knows exactly what his or her lifetime labor income will be. However, at the beginning of one's working life, lifetime income is uncertain and this uncertainty affects expected utility. Social Security provides a hedge with respect to lifetime earnings by providing proportionately higher retirement payments to those whose ex-post earned income is lowest.

To incorporate income uncertainty into our expected utility estimates, we calculate expected utility from the perspective of a worker who has not yet entered the workforce and has complete uncertainty about his or her future income (a worker at birth). We assume that with equal probability the worker will realize the income of any of her cohort members and then we simulate 10,000 investment return paths. We then calculate the level of risk aversion for which this worker is indifferent between the distribution of retirement incomes he will receive with Social Security (which depend only upon his income path) and the distribution of PRA annuity payments (which depend upon his income path and investment returns). Following Feldstein and Ranguelova (2001), we also calculate the level of risk aversion for which a representative worker, who earns the average income of his cohort each year, is indifferent between promised Social Security retirement payments and the distribution of PRA annuity payments.

The results of this analysis are presented in Table 2. The worker at birth (Panel A) with equal likelihood of earning any of his cohort's lifetime earnings is indifferent between Social Security and a PRA without choice for a risk-aversion parameter of 1.78 while the representative worker who earns his cohort's mean income each year is indifferent between Social Security and a PRA without choice for a risk-aversion parameter of 5.65. The representative worker has a stronger preference for PRAs, as he is indifferent between Social Security and the PRA at much higher levels of risk-aversion than the worker at birth.

One way to think about the economic significance of the observed difference in the risk aversion parameters that leave the representative worker vs. the worker at birth indifferent between Social Security and PRAs is to engage in the following thought exercise: Assume that the worker at birth is endowed with a risk aversion parameter of 5.65, the risk aversion parameter at which the representative worker is indifferent between Social Security and a PRA system. By how much could Social Security payments be reduced before the worker at birth would prefer PRAs to Social Security? The worker at birth with a risk-aversion parameter of 5.65 would be willing to accept reductions in Social Security payments up to 61% before preferring PRAs to Social Security. Clearly the representative worker benefits much more from a switch to a PRA than do most workers and his preferences and welfare are not representative of his cohort.

As documented in Table 2, for each of the three choice scenarios, the representative investor has higher breakeven risk aversion parameters than the worker at birth. In untabulated calculations we find that, for each choice scenario, when we endow the worker at birth with the risk aversion parameter for which the representative investor is indifferent between PRAs and Social Security, the worker at birth would be willing to accept reductions in Social Security payments ranging from than 64% to 84% before preferring PRAs to Social Security.

Why is the representative worker happier with a PRA than a worker at birth? First, the representative worker does not face income uncertainty. Second, his annual income is above his cohort's median annual income (though below the income cap on Social Security taxes). Thus he does not benefit from the progressivity of Social Security benefits. And, third, unlike most workers, he earns income for 47 years. Only the top 35 of these years contribute to his AIME and Social Security benefits, but all 47 years contribute to his PRA savings. This increases the appeal to him of PRAs. In lifetime income, representative worker is much wealthier than most of his peers. Measured in nominal dollars, the representative worker's lifetime income is nearly double that of the median worker, $3,757,423 versus $2,000,641.

Social Security provides a better return on savings for the lowest income workers. However, a number of features of Social Security prevent it from consistently redistributing wealth from higher-income to lower-income workers. Liebman (2002, p.12) writes: "However, much of the intracohort redistribution in the U.S. Social Security system is related to factors other than income. Social Security transfers income from individuals with low life expectancies to those with highlife expectancies, from single workers and from married couples with substantial earnings by the secondary earner to married one-earner couples, and from individuals who have worked for more than thirty-five years to those who have concentrated their earnings in thirty-five or fewer years."

In our analysis, PRA savings are automatically invested in annuities. Thus, workers who die early in retirement reap lower total retirement income from both Social Security and the PRA system and conditional mortality does not affect our analysis. If savings were not annuitized but held in private accounts after retirement, workers who died early in retirement might derive additional benefit from the PRA system through bequests. However, without annuitizing PRA savings, the payouts from PRAs would be lower and all workers would face considerable longevity risk.

Our analysis is at the individual level. To the extent that higher income individuals are likely to be married to non-working spouses, we underestimate the relative benefits of Social Security to the higher income quintiles (see Brown, Coronado, and Fullerton, 2009). Doing so does not affect our results on choice; choice reduces welfare for all income groups. However, if we underestimate the relative benefits of Social Security to higher-income workers, we may overestimate the level of risk aversion for which the representative worker is indifferent between Social Security and a PRA-based system. We do not, however, intend our estimates of risk aversion to be precise calibrations. Indeed, as discussed above, it is unlikely that most people have constant relative risk aversion utility. Our goal in presenting results for a representative worker is to illustrate that as long as Social Security provides a better average return on savings to lower income workers, the welfare of the representative worker will not be representative of the welfare of his cohort.

III.C. Income Shortfalls

C. 1. All Workers

Income shortfalls across all workers are presented in Table 3 Panels A and B. Without stock investment or allocation choice (top left, Panel A), the probability of an income shortfall ranges from 17.9% at age 68 to 26.6% at age 88. Solely allowing allocation choice while restricting stock investment choice (bottom left, Panel A) increases the probability of an income shortfall with a range of 22.8% at age 68 to 30.8% at age 88. Solely allowing stock investment choice while restricting allocation choice (top right, Panel A), has a larger impact on the probability of an income shortfall, with a range of 30.6% at age 68 to 36.7% at age 88. Allowing both allocation and stock investment choice (bottom right, Panel A) yields a further increase in the probability of an income shortfall to 41.0% at age 88.

One problem with our income shortfall metric is that it does not distinguish between small and serious shortfalls: 45% of workers experiencing an income shortfall of less than 5% relative to Social Security might not greatly affect welfare. However, income shortfalls are not only common, but also material. We define the payout ratio as the ratio of PRA income to Social Security income. Across all simulations and workers, we calculate the payout ratio. In Figure 3, we plot the kernel density of the payout ratio for payout ratios less than 4. (The distribution has a long thin tail above 4.) For both the no choice and allocation/equity choice scenarios, the probability density function peaks below 1.0, but the peak occurs at a lower point in the distribution when we allow for both allocation and equity choice. As a result, conditional on observing an income shortfall, a worker's expected retirement income at age 88 is 67% of the promised Social Security benefit at age 88 in the no choice scenario and 55% of the promised Social Security benefit with both allocation and equity choice.

In Panel B, we present percent-at-risk. These results indicate a substantial percentage of the worker population has greater than a 25% probability of an income shortfall and the percent-at-risk increases dramatically with investment choice. Without allocation or stock investment choice, the percent-at-risk is 29.7% at age 68 and 42.2% at age 88. With allocation choice, the percent-at-risk is 36.0% at age 68 and 52.4% at age 88. With both allocation choice and equity choice, the percent-at-risk is 61.3% at age 68 and 81.9% at age 88.

Three common patterns emerge in these simulations. First, the probability of an income shortfall increases with age. The erosion of the performance of the PRA with age can be traced to the observation that the median payout from the variable annuity grows less than the mean payout in retirement years. To see this, consider a worker who retires at age 67 with $100 savings. The worker buys a 33-year variable annuity with an 8% expected return, 14% standard deviation, and 3% growth rate (in the same ballpark as the returns on the 50/50 stock/bond portfolio).[22] We simulate the payouts the worker can expect from this variable annuity at each age from 66 to 100. Figure 4 depicts the 25th percentile, median, 75th percentile, and mean outcome at each age across the simulations. Note the average outcome from the variable annuity is precisely what the worker would expect from a straight annuity (i.e., no return variance) with an 8% expected return and 3% growth rate. Per $100 investment, the straight annuity would pay $6.32 at age 68, $16.28 at age 100, and grow by precisely 3% in each year.[23] However, the gap between the mean and median payout from the variable annuity increases with age. This result can be traced to the increased volatility of outcomes associated with the market risk borne by the worker who purchases a variable annuity.

Second, the probability of an income shortfall increases with equity choice. The preceding discussion also explains why workers are more likely to experience an income shortfall when faced with more stock investment choice. Some workers will fail to diversify completely, which will increase the volatility of their outcomes. Increased volatility of investment outcomes does not affect the average return earned by workers. In each period, workers in aggregate earn the same return, regardless of choice. However, choice induces more volatility and skewness in worker outcomes over time, which causes the

[22] In these simulations, we assume the log return of the portfolio is normally distributed with a mean of 6.9% and a standard deviation of 12.9%. This corresponds to a level return of 8% and a standard deviation of 14%. The 3% growth rate is intended to keep expected annuity payments constant by adjusting for inflation.

[23] The $6.32 annuity payout at age 68 represents is based on the 33-year annuity factor at an 8% discount rate, 3% growth rate, and an assumed investment portfolio of $100 at age 65, $100/15.82 = $6.32.

median worker outcome to drop and thus increases the probability of an income shortfall under the PRA scheme.

Third, allocation choice also increases the probability of an income shortfall. The main reason for the increased shortfall risk when we allow allocation choice is that many workers make relatively small allocations to stock. Workers who choose lower allocations to stock have a greater probability of an income shortfall in retirement because of the low average expected return on their investment portfolio. We verify this conclusion by sorting households into quintiles based on their stock/bond allocation in the allocation choice simulations. The top two quintiles have mean allocations to stocks of 66 and 97% (respectively), and simulation results for these households are very close to our baseline results with a fixed 50/50 stock/bond allocation. Thus, the higher expected returns that result from a relatively high allocation to stocks offset the higher volatility that results from the riskier allocation. However, the bottom allocation quintile has an average stock allocation of only 3%. For these workers the probability of an income shortfall jumps from 17.9% at age 68, if they are required to hold a fixed 50/50 stock/bond allocation without investment choice, to 37.6% if they choose a low allocation to equities. The same basic patterns appear at other ages and when we consider the percent-at-risk measures. Over the long periods for which we simulate returns, stocks usually outperform bonds. Thus, in our simulations PRAs outperform Social Security more often when they invest in substantial equity positions. However, as discussed in Section IV, our assumption that annual logged equity returns are normally distributed likely underestimates the likelihood of poor equity performance over long periods.

C. 2. Results by Income

These results indicate that investors in PRAs have increasing probability of income shortfalls relative to their promised Social Security benefit with increasing choice. In this section, we document that while the probability of an income shortfall varies dramatically across income groups—a result which can be traced to the progressive nature of Social Security benefits—choice adversely affects outcomes for all income groups

To investigate this issue, we partition workers into quintiles based on indexed lifetime earnings to age 67. The results of this analysis are presented in Table 3 Panels C and D. In Panel C, we present worker outcomes for each income quintile. With no allocation or stock investment choice, there are dramatic differences in outcomes by income quintile due largely to the progressive nature of Social Security benefits. The probability of an income shortfall for a worker from the lowest income quintile ranges from 44.5% at age 68 to 49.2% at age 88, while the same probability for a worker from the highest income quintile ranges from 1.8% at age 68 to 8.5% at age 88. Consistent with our earlier findings, for all income groups, both allocation choice and equity choice increase the probability of a shortfall.

In Panel D, we present the percent-at-risk and the distributional effects of PRA accounts are even starker. Without allocation or stock investment choice, *no one* in the top income quintile has a greater than a 25% probability of experiencing a PRA income less than their promised Social Security benefit. With equity choice, the percent-at-risk among the top-quintile wage earners ranges from 0% at age 68 to 10.5% at age 88. In contrast, the entire population of the low-income wage earners (the bottom 20% of lifetime indexed earnings, discussed above) has greater than a 25% probability of an income shortfall in retirement (regardless of the choice scenario). With allocation choice, nearly all workers in the bottom two income quintiles have greater than a 25% risk of an income shortfall. With stock investment choice, all workers in the bottom three quintiles face this risk at age 88. Again, choice adversely affects outcomes for all income groups.

C. 3. Results by Market Outcomes

To investigate how market outcomes affect generational outcomes, we partition simulations into quintiles based on the market return earned during the cohort's savings years. The results of this analysis are presented in Table 3 Panels E and F.

Not surprisingly, market risk plays a huge role in the attractiveness of PRAs. The mean level return on the 50/50 stock/bond portfolio in the bottom quintile of generational outcomes is 5.2% – a mere 2.2% over inflation. The probability of an income shortfall in these bottom-quintile market outcomes is quite high, ranging from 49.6% at age 68 to 55.5% at age 88 across all workers. The percent-at-risk is also high; over 90% of workers have greater than a 25% probability of an income shortfall at age 88 during bottom-quintile market outcomes. Choice continues to increase the probability of an income shortfall during these poor market conditions.

In strong (top quintile) market conditions, the portfolio earns a return of 10.0%. Without choice, workers have a low probability of an income shortfall (ranging from 1.1% at age 68 to 5.9% at age 88). Allocation choice increases these probabilities (ranging from 4.9% at age 68 to 11.2% at age 88), while equity choice increases them dramatically (ranging from 8.6% at age 68 to 15.5% at age 68) and the combination of allocation and equity choice even more (12.9% at age 68 and 20.6% at age 88). Thus, even in strong market conditions, about $1/5^{th}$ of the worker population experiences income shortfalls at age 88 with allocation and equity choice. Similarly, the percent-at-risk in these high return outcomes is very low (ranging from 1.0% at age 68 to 3.5% at age 88). However, with allocation choice, the percent-at-risk increases (ranging from 2.2% at age 68 to 11.2% at age 88). Equity choice increases this risk, ranging from 6.7% at age 68 to 20.2% at age 88. With both equity and allocation choice, this risk increases to 17.6% at age 68 and 31.3% at age 88. These results indicate a sizable fraction of workers – almost $1/3^{rd}$ at age 88 – face greater than a 25% risk of an income shortfall even in the best market conditions when both allocation and equity choice are allowed.

IV. Discussion

Our simulations compare the outcomes from PRAs with various levels of choice to promised Social Security benefits. Simulating Social Security outcomes provides a benchmark against which to compare levels of choice in PRA systems and allows us to demonstrate the shortcoming of a using a representative worker to capture the utility of all workers.

As a direct comparison of PRA systems to Social Security, our simulations are illustrative, not definitive. There are many dimensions of Social Security and PRAs that we do not attempt to model. We compare Social Security and PRAs as self-funded retirement plans for a single cohort. Our Social Security simulation assumes risk free real log return equal to the real log return on five-year government bonds during the post-war period (1946-2008). We do not consider Social Security's liabilities resulting from net transfers to people born before 1937, how these liabilities would be paid in the transition to a PRA system, or the political uncertainty resulting from these liabilities.

Feldstein (1997, p.22) argues one advantage of a PRA type system is the increased availability of capital for private investment, which he argues could drive down the return on capital by 20% (from historic average of 9% to 7.2%); Geanakpolos, Mitchell, and Zeldes (p. 127, 1999) make a similar point. Lower returns on capital are the equivalent of lower expected returns for investors. Lower expected returns would make PRAs less attractive to workers, but the increased investment could generate positive externalities. We do not consider either the effect of lower returns or additional investment in our simulations.

In many ways, the outcomes we present underestimate the potential income shortfalls and the distributional effects of PRAs. In the PRA scheme we model, we have prohibited bequests, forced purchase of variable annuities, assumed investors who self-manage their accounts do not pay high fees or sacrifice expected returns, and assumed all investors have the same ability to pick stocks and mutual funds. Furthermore, our distributional assumptions likely underestimate the probability of dramatically poor equity returns. We discuss each of these factors in turn.

We have pooled bequests and ignored variation in outcomes during retirement years. Our implementation of PRAs assumes that any remaining balance in the PRA when a worker dies is used to fund payouts for living cohort members. If workers were allowed to bequest the remainder of their PRA, payouts from PRAs would be reduced and the probability of an income shortfall would increase. If workers were not forced to buy a variable annuity in their retirement years, many would continue to self-manage their accounts. Few U.S. households currently buy annuities, an observation referred to as the "annuity puzzle." (Inkman, Lopes, and Michaelides 2011 present recent evidence on the annuity puzzle.) The continued self-management of PRAs would further increase the volatility of outcomes across workers and increase the probability of income shortfalls.

We do not charge a performance penalty to workers who self-manage their portfolios. There is considerable evidence that individual investors underperform appropriate benchmarks when managing their own investment portfolios (Barber and Odean 2000; Barber and Odean 2001; Grinblatt and Keloharju 2001; Barber, Lee, Liu, and Odean 2009). Furthermore, the average mutual fund charges expenses far greater than the 40 bps assumption used in our simulations. Khorana, Servaes, and Tufano (2008) document asset-weighted average bond and stock expense ratios in the US are 0.78% and 1.11%, respectively. Including load fees amortized over a five-year holding period, total shareholder costs for bond and stock funds are 1.05% and 1.53%, respectively. Attaching a performance penalty or higher fees to self-managed investment accounts would further erode the performance of PRAs and increase the probability of an income shortfall.

We do not consider predictable variation in performance across investors. In our simulations, we assume all investors earn the same expected return. However, there is strong evidence that investment outcomes predictably vary across investors (see Barber and Odean 2011 for a review). For example, the wealthy tend to earn stronger returns than the poor (Barber and Odean 2000), and the young perform better than the old (Korniotis and Kumar 2011). High IQ investors earn stronger returns than low IQ investors (Grinblatt, Keloharju, and Linnainmaa 2011) and also pay lower fees on their mutual funds (Grinblatt, Ikäheimo, Kelaharju, and Knupfer 2012). Thus, the combined evidence provides strong support for the possibility that young, wealthy, and smart investors will earn stronger returns than others. Adding this cross-sectional variation in expected returns would increase the differences in outcomes for low- and high-income workers.

We do not model the well-documented relation between stock market participation and wealth (Campbell 2006). In our simulations that allow allocation choice, we find that a low allocation to stocks results in a lower expected return on a worker's investment portfolio and a much higher probability of an income shortfall. If low-income wage earners are less likely to allocate their investment portfolio to stocks, the probability of a shortfall for low-income workers will be higher than the estimates we obtain.

Finally, our simulations underestimate the probability of bad market outcomes. In our simulations, we assume that equity index returns follow a lognormal distribution, which implies logged returns are normally distributed. However, empirically observed logged returns are negatively skewed.[24] Thus our simulation underestimates the likelihood of large negative equity returns. As discussed above, we estimate the mean and standard deviation of logged returns from 1946–2008 historical returns, reducing the mean by 2 percentage points in response to recent academic estimates of the equity risk premium. We assume that the returns earned in sequential years are independent and thereby ignore the possibility that a

[24] Over the 1946-2034 sample period, the skewness coefficient of the annual logged return on the S&P 500 is -0.90 ($p<.01$).

crisis in financial markets may feedback into the real economy thereby affecting subsequent market returns. Thus we underestimate, perhaps severely, the probability that equity markets will underperform over long periods. To illustrate this point, imagine that at the beginning of 1990 one had estimated the mean annual logged return and variance of the Japanese stock market from 1947 through 1989.[25] Forecasting the distribution of returns from 1990 through 2012, one would have estimated that the realized 22-year logged return of -0.44 had a probability of less than 1.5 in 10 million (0.000000147). Had one reduced the assumed mean logged return by 2 percentage points—as we do the historical mean logged return in our simulations—one would have estimated the realized 22-year logged return had a probability of 0.00000116. This example highlights the dangers of forecasting from historical returns. While one in a million events do occur, biased econometric models are more common. Our simulations underestimate the likelihood of poor market performance over long horizons. We choose to acknowledge this bias rather than attempt to compensate with controversial ad hoc assumptions.

V. Conclusion

We simulate retirement outcomes for a representative sample of U.S. workers in private retirement account (PRA) systems with varying degrees of choice and compare these to expected payoffs from the current U.S. Social Security system. When workers are required to invest PRA savings in a stock and bond index fund, we document that across all simulations 17.9% of age 68 retirees and 26.6% of age 88 retirees have PRA payouts that fall below their currently promised Social Security benefit. With allocation choice, the risk of lower income increases to 22.8% at age 68 and 30.8% at age 88; with equity choice, it grows to 30.6% at age 68 and 36.7% at age 88; with both allocation and equity choice, it grows to 34.9% at age 68 and 41.0% at age 88.

Our analysis of the utility over retirement income indicates that choice reduces the potential upside associated with PRA outcomes even at modest levels of risk aversion. For example, at a risk aversion level of 3.8, 36.9% of workers prefer Social Security to PRAs with no allocation or equity choice, but virtually all workers (98.2%) prefer Social Security to PRAs with allocation and equity choice.

A representative worker who earns the average wage of his cohort during each year of his life has a stronger preference for PRAs—with or without choice--than does a worker chosen randomly at birth. PRAs are more appealing to the representative worker because he faces no lifetime income uncertainty, he earns much more than the median income of his cohort, and he works for 47 years (while Social Security benefits are based on the top 35 years of indexed earnings). In short, the welfare of the representative worker is not representative of most workers' welfare.

[25] For this analysis, we use the Global Financial Data Japan Nikko Securities Composite Total Market Return Index.

Our simulations focus on choice in PRAs as an alternative to Social Security. However, our central message applies more broadly to self-directed retirement plans, including 401(k) plans. Offering workers more investment choice is likely to reduce the standard of living in retirement for many of them.

Most models in economics presume that agents are better off with more choice or with a larger opportunity set. However, this is only true for investors if they are equipped with the knowledge, skill, and discipline to select optimal investment portfolios. If investors fail to diversify, underperform benchmarks, pay high fees, or refrain from participating in stock markets, choice will not necessarily lead to better outcomes. Indeed, many investors will be made poorer by choice.

Figure 1: Cohort mortality

This figure presents cohort mortality as a function of age based on the number of individuals alive at age 21. Data are from the 1979 CORSIM cohort simulation.

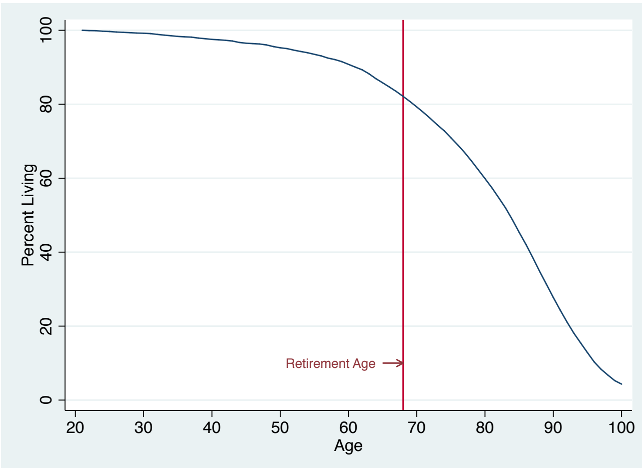

Figure 2: Stock Allocation in Retirement Accounts

The figure depicts the percentage allocation to stocks in IRA/Keogh/401K accounts for households with investments in at least one retirement account and the head of household is less than age 68 in the 2010 Survey of Consumer Finances dataset.

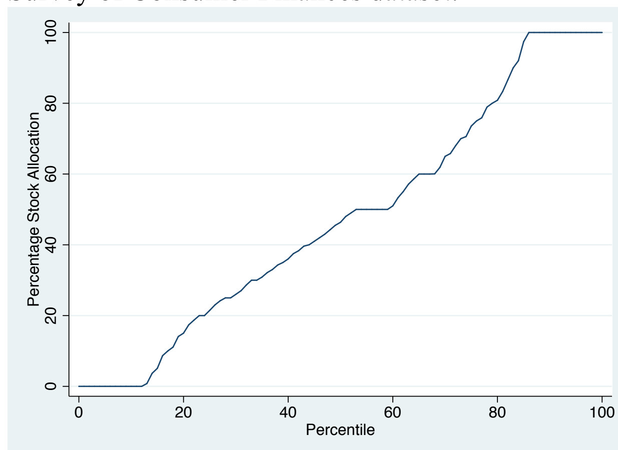

Figure 3: The Distribution of Payout Ratios at age 88

This figure depicts the distribution of the payout ratio, defined as the ratio of PRA income to promised Social Security benefits, across all workers and simulations for two scenarios: (1) No Choice and (2) Allocation and Equity Choice

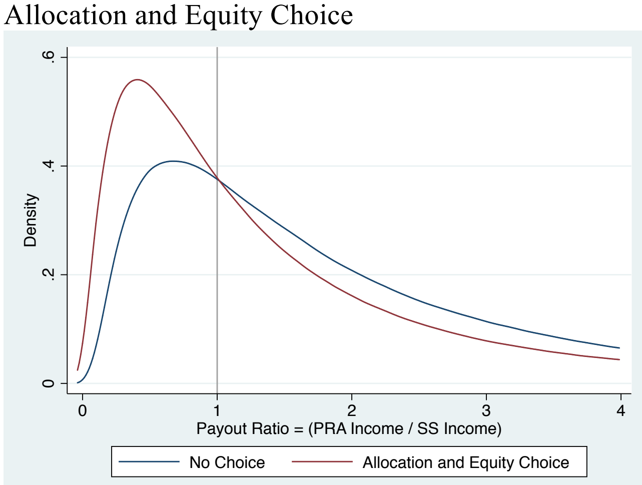

Figure 4: Distribution of Variable Annuity Payout by Age

This figure depicts the distribution of the annual payout at various ages for a $100 variable annuity purchased at age 67. The parameters used to calculate the payout are a 3% growth rate, 8% expected return, and 14% standard deviation of returns.

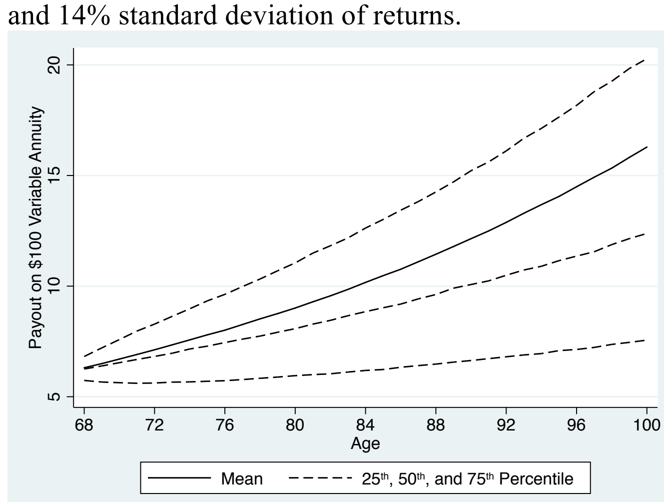

Table 1: Percentage of Population Preferring Social Security to Private Retirement Accounts at Different Levels of Relative Risk Aversion (γ)

This table presents the percentage of the population that prefers Social Security to Private Retirement Accounts at relative risk aversion parameters (γ) of 2.0, 3.8, and 5.65. We assume workers have utility over consumption, $u(C_t)$, with constant relative risk aversion:

$$u(C_t) = \frac{{C_t}^{1-\gamma} - 1}{1-\gamma}$$

and calculate expected lifetime utility ($E[u]$) assuming a discount rate β=0.96:

$$E[u] = E\left[\sum_{t=68}^{100} \beta^{t-68} u(C_t)\right]$$

Expected lifetime utility under Social Security is based on the promised benefits; expected lifetime utility under the PRA system is the average utility across simulations.

	γ	No Investment Choice	With Investment Choice
		Panel A: All Workers	
50/50	2.00	20.3	38.3
Stock/Bond	3.80	36.9	79.7
Allocation	5.65	60.5	97.6
Stock/Bond	2.00	30.6	55.2
Allocation	3.80	50.8	98.2
Choice	5.65	79.1	100.0

Panel B: By Quintile of Lifetime Earnings

		No Investment Choice: Quintile of Lifetime Earnings					With Investment Choice: Quintile of Lifetime Earnings				
		1 (Lo)	2	3	4	5 (Hi)	1 (Lo)	2	3	4	5 (Hi)
50/50	2.00	77.6	24.0	0.2	0.0	0.0	100.0	85.2	6.6	0.0	0.0
Stock/Bond	3.80	100.0	80.1	4.6	0.0	0.0	100.0	100.0	99.6	81.9	17.0
Allocation	5.65	100.0	99.6	79.5	23.3	0.0	100.0	100.0	100.0	100.0	87.9
Stock/Bond	2.00	99.3	43.3	3.8	3.4	3.6	100.0	99.6	62.3	14.0	0.0
Allocation	3.80	100.0	98.6	46.8	5.2	3.6	100.0	100.0	100.0	100.0	91.3
Choice	5.65	100.0	100.0	98.9	78.7	18.0	100.0	100.0	100.0	100.0	100.0

Table 2: Risk Aversion Parameter (γ) that leaves the Worker at Birth and Average Worker indifferent between Social Security and PRAs

The table presents the risk aversion parameter (γ) that equates the utility from Social Security benefits to the expected utility across PRA outcomes. Panel A presents results for a worker at birth that has an equal probability of earning the lifetime income of each member of his cohort. Panel A presents results for the worker who earns the average wage of his cohort in each year. We assume workers have utility over consumption, $u(C_t)$, with constant relative risk aversion:

$$u(C_t) = \frac{{C_t}^{1-\gamma} - 1}{1-\gamma}$$

and calculate expected lifetime utility ($E[u]$) assuming a discount rate β=0.96:

$$E[u] = E\left[\sum_{t=68}^{100} \beta^{t-68} u(C_t)\right]$$

For the average worker (Panel A), expected lifetime utility under Social Security is based on the promised benefits; expected lifetime utility under the PRA system is the average utility across simulations. For the worker at birth (Panel B), expected lifetime utility under Social Security is the average utility of Social Security benefits across workers; expected lifetime utility under PRA system is the average utility across workers and simulations.

	No Stock Investment Choice	With Stock Investment Choice
Panel A: Worker at Birth		
50/50 Stock/Bond Allocation	1.78	1.47
Stock/Bond Allocation Choice	1.60	1.32
Panel B: Worker who Earns Average Wage		
50/50 Stock/Bond Allocation	5.65	3.09
Stock/Bond Allocation Choice	4.73	2.38

Table 3: Retirement Outcomes for Private Retirement Accounts v. Social Security

The table simulates outcomes for 10,000 generations of workers who save 8.8% of their income during working years and invest the proceeds in a 50/50 stock/bond portfolio. Each generation includes over 3,000 representative worker income profiles; income profiles are static across simulations. The log returns on stocks and bonds are drawn from a bivariate normal distribution with means of 7.6% and 5.1%, standard deviations of 17.4 and 9.7%, and a correlation of 25%. When households are allowed choice in their stock investments, we increase the standard deviation of the stock return at the household level to 29.6% while retaining the same aggregate level return on stocks.

Worker Outcomes represent the percentage of outcomes across simulations where the worker has lower retirement income from PRA than promised Social Security benefit.

Percent at Risk represents the percentage of workers where retirement income across PRA simulations is lower than promised Social Security benefit in more than 25% of simulations.

All Workers

	Age	No Stock Investment Choice	With Stock Investment Choice
Panel A: Worker Outcomes (% PRA < SS Benefit)			
50/50	68	17.9	30.6
Stock/Bond	78	23.2	34.4
Allocation	88	26.6	36.7
Stock/Bond	68	22.8	34.9
Allocation	78	27.8	38.8
Choice	88	30.8	41.0
Panel B: Percent at Risk (% of workers for whom PRA < SS Benefit in >25% of simulations)			
50/50	68	29.7	52.1
Stock/Bond	78	36.3	66.1
Allocation	88	42.2	74.6
Stock/Bond	68	36.0	61.3
Allocation	78	44.1	75.8
Choice	88	52.4	81.9

Workers sorted into quintiles based upon earnings through age 65 and present outcomes by income quintiles.

		No Stock Investment Choice across Lifetime Earnings Quintiles					Stock Investment Choice across Lifetime Earnings Quintiles				
	Age	1 (Lo)	2	3	4	5 (Hi)	1 (Lo)	2	3	4	5 (Hi)
		Panel C: Worker Outcomes (% PRA < Social Security Benefit)									
50/50 Stock/Bond Allocation	68	44.5	26.9	10.7	5.5	1.8	56.0	41.8	26.1	18.8	10.4
	78	48.6	33.3	17.3	11.3	5.4	58.0	45.2	30.6	23.5	14.8
	88	49.2	35.8	21.2	15.3	8.5	58.0	46.2	32.9	26.2	17.4
Stock/Bond Allocation Choice	68	51.4	34.1	16.0	9.1	3.4	62.5	47.5	29.9	21.7	12.8
	78	53.9	39.1	22.4	15.4	8.0	63.6	50.5	34.9	27.2	17.7
	88	53.8	40.7	25.9	19.2	11.3	63.0	51.1	37.1	30.0	20.6
		Panel D: Percent at Risk (% of workers for whom PRA < SS Benefit in >25% of simulations)									
50/50 Stock/Bond Allocation	68	97.5	50.1	0.9	0.0	0.0	100.0	100.0	58.4	2.1	0.0
	78	100.0	76.3	5.9	0.0	0.0	100.0	100.0	95.0	33.0	0.0
	88	100.0	90.6	12.4	0.8	0.0	100.0	100.0	99.1	66.8	0.0
Stock/Bond Allocation Choice	68	100.0	76.9	3.0	0.0	0.0	100.0	100.0	86.6	20.0	0.0
	78	100.0	98.9	20.6	0.5	0.0	100.0	100.0	100.0	74.5	2.5
	88	100.0	100.0	51.1	4.2	0.0	100.0	100.0	100.0	92.9	10.5

Simulations sorted into quintiles based upon the market returns earned during savings years.

		No Investment Choice across Simulation Return Quintiles					With Investment Choice across Simulation Return Quintiles				
		1 (Lo)	2	3	4	5 (Hi)	1 (Lo)	2	3	4	5 (Hi)
	Age	5.2%	6.7%	7.6%	8.5%	10.0%	5.2%	6.7%	7.6%	8.5%	10.0%
		Panel E: Worker Outcomes (% PRA < Social Security Benefit)									
50/50 Stock/Bond Allocation	68	49.6	23.2	11.1	4.3	1.1	58.2	39.2	28.2	18.8	8.6
	78	54.0	31.2	18.2	9.1	3.4	60.3	43.7	32.7	23.0	12.5
	88	55.5	36.0	22.9	12.8	5.9	60.9	46.2	35.5	25.5	15.5
Stock/Bond Allocation Choice	68	52.5	28.7	17.6	10.4	4.9	60.6	43.4	33.3	24.1	12.9
	78	56.1	35.6	23.7	15.0	8.3	62.7	47.9	37.7	28.3	17.4
	88	57.2	39.6	27.7	18.3	11.2	63.2	50.1	40.4	30.7	20.6
		Panel F: Percent at Risk (% of workers for whomPRA < SS Benefit in >25% of simulations)									
50/50 Stock/Bond Allocation	68	69.2	33.9	18.6	5.0	1.0	93.6	68.0	44.3	31.0	6.7
	78	84.3	46.0	26.9	14.3	2.0	98.7	80.7	57.1	36.6	14.6
	88	92.3	58.4	35.7	20.1	3.5	100.0	86.9	66.7	41.6	20.2
Stock/Bond Allocation Choice	68	76.9	40.2	27.6	14.9	2.2	94.6	74.1	52.6	36.6	17.6
	78	88.2	56.3	36.7	21.5	5.6	99.9	86.3	69.9	45.0	24.8
	88	94.7	70.6	44.0	26.2	11.2	100.0	93.0	78.5	52.9	31.3

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Online Appendix A: Descriptive Statistics

Table A1: Cohort earnings by age

This table reports summary statistics for earnings of individuals in the CORSIM data (1979 birth year) by age.

			Earning Statistics					
Year	Age	No. Living	Mean	Median	Std. Dev	75%	25%	No. (=0)
1999	20	3,619	8,297	4,429	10,925	12,330	48	883
2009	30	3,585	41,814	28,055	53,913	63,199	4,466	599
2019	40	3,525	76,544	48,480	110,507	108,741	6,710	634
2029	50	3,443	121,688	72,085	189,085	167,242	7,131	679
2039	60	3,281	121,217	21,725	289,070	155,679	0	1,293
2049	70	2,866	39,647	0	244,837	0	0	2,302
2059	80	2,165	16,673	0	105,647	0	0	1,959
2069	90	1,003	2,169	0	20,542	0	0	976

Table A2: Annual Level and Log Household Returns

Household returns are based on data from a large discount broker from 1991 to 1996. The table presents mean annual level and log returns for equity (mutual funds and individual stocks) investments in tax-deferred accounts across households. Returns are before transaction costs (loads and redemption fees on mutual funds, commissions and bid-ask spread on common stocks). Mutual fund returns are net of operating expenses. The market return is based on the total return on the S&P 500 index.

		Level Return			Log Return	
	Households	Mean	Std. Dev.	Market Return	Mean	Std. Dev.
1991	16,116	34.6	47.5	33.6	25.5	28.1
1992	19,568	8.7	28.5	9.0	5.0	26.9
1993	21,800	15.5	26.2	11.5	12.0	22.1
1994	23,278	-4.0	18.8	-0.6	-6.1	21.4
1995	23,607	32.9	31.5	35.7	26.1	22.1
1996	24,250	21.1	29.6	21.3	16.5	23.7
Mean	21,437	18.1	30.4	18.4	13.2	24.0

Online Appendix B: Benefit Calculations

In this appendix, we describe the calculation of Social Security benefit levels used in our simulations.

Average Indexed Monthly Earnings (AIME) and Bend Points

To calculate the promised benefit for an individual worker, we first index the worker's capped annual wages to age 60 (wages earned after age 60 are not indexed). Capped wages in each year represent the lower of the worker's actual wage and the maximum wage subject to Social Security taxes and eligible for benefits. The index rate represents changes both in cost of living and real wage rates and tends to exceed inflation (specifically the index depends on CPI-W published by the Bureau of Labor Statistics). Of indexed wages, the top 35 years are used to calculate Average Indexed Monthly Earnings ("AIME").

AIME is compared to two benefit cutoff levels ("Bend Points"). The worker's retirement benefits are calculated by adding 90% of wages below the first Bend Point, 32% of wages between the two Bend Points, and 15% of wages above the second bend point. Figure A-1 illustrates the application of Bend Points to AIME for the cohort retiring in 2014. The Bend Points introduce concavity into retiree benefits as a function of preretirement income.

Each year, the Social Security Administration calculates an Average Wage Index (AWI) based on prevailing wages subject to Social Security tax. Historically, the increases in Bend Points have been close to increases in the Average Wage Index. Our analysis uses the same parameter to increase both of these items. We use the compound annual growth rate of changes to bend points from 1980 to 2010 to estimate a base case index rate of 4%; this rate is used to index wages and Bend Points to retirement-age (2047) price levels.

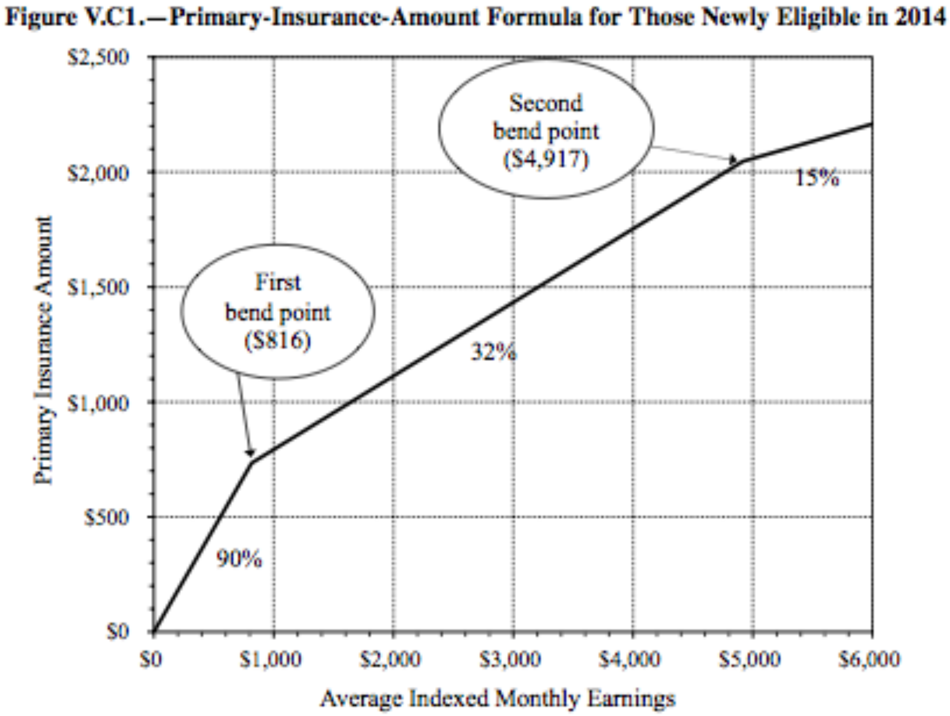
Benefit Base

The Benefit Base represents the maximum wage subject to Social Security taxes. Wages that exceed the Benefit Base in any year are set equal to the Benefit Base in the calculation of benefits. The cap for 2014 is $117,000; to estimate future Benefit Base levels we use a growth rate of 4%, which equals the assumptions we make regarding wage inflation and is close to the 3.9% compound annual growth rate of the Benefit Base between 1985 and 2010 (see http://www.ssa.gov/oact/cola/cbb.html).

Annual benefits are adjusted each year to reflect cost of living increases. In scenario analysis, Board of Trustees (2012, p.8) estimates future cost of living increases to be between 1.8% and 3.8%. We use 3%, which is close to the realized benefit increase for the period from 1985 to 2010 of 2.8%[1] and is near the midpoint of the Board of Trustees range. In Table A1, we provide and example of a worker earnings history. In Table A2, we present the estimated benefit for the worker. All numbers in both tables are nominal, not real.

[1] See http://www.ssa.gov/oact/cola/colaseries.html.

Figure B-1: Bend points and Average Indexed Monthly Earnings (AIME)



Source: Board of Trustees 2014 Report, p.112.

Table B1: Worker Earnings History

Year	Age	Capped Earnings	Wage Index Factor	Earnings in Age 60 $
2000	21	21,020	4.6164	97,034
2001	22	18,295	4.4388	81,209
2002	23	23,328	4.2681	99,567
2003	24	26,752	4.1039	109,788
2004	25	24,551	3.9461	96,881
2005	26	28,627	3.7943	108,620
2006	27	33,482	3.6484	122,155
2007	28	33,468	3.5081	117,408
2008	29	39,956	3.3731	134,778
2009	30	46,066	3.2434	149,410
2010	31	45,809	3.1187	142,861
2011	32	30,514	2.9987	91,503
2012	33	32,595	2.8834	93,982
2013	34	35,047	2.7725	97,168
2014	35	49,920	2.6658	133,079
2015	36	56,386	2.5633	144,535
2016	37	65,134	2.4647	160,538
2017	38	65,938	2.3699	156,268
2018	39	71,408	2.2788	162,721
2019	40	63,575	2.1911	139,301
2020	41	67,966	2.1068	143,194
2021	42	76,308	2.0258	154,585
2022	43	90,960	1.9479	177,180
2023	44	82,743	1.8730	154,977
2024	45	82,124	1.8009	147,901
2025	46	89,514	1.7317	155,010
2026	47	93,750	1.6651	156,101
2027	48	99,855	1.6010	159,872
2028	49	84,943	1.5395	130,765
2029	50	75,575	1.4802	111,870
2030	51	96,220	1.4233	136,951
2031	52	115,240	1.3686	157,714
2032	53	88,465	1.3159	116,414
2033	54	91,927	1.2653	116,317
2034	55	91,788	1.2167	111,674
2035	56	109,443	1.1699	128,033
2036	57	106,964	1.1249	120,320
2037	58	118,064	1.0816	127,698
2038	59	18,851	1.0400	19,605
2039	60	17,329	1.0000	17,329
2040	61	6,162	1.0000	6,162
2041	62	9,914	1.0000	9,914
2042	63	6,383	1.0000	6,383
2043	64	9,900	1.0000	9,900
2044	65	27,554	1.0000	27,554
2045	66	12,546	1.0000	12,546
2046	67	0	1.0000	0

Table B2: Calculation of Social Security Benefit

		Bend Rates	Bend Points
Sum of top 35 years of earnings:	4,678,689		
Average Monthly Indexed Earnings (AIME)	11,140 [a]		
Amount from Bend 1	2,724 [b]	90%	3,027
Amount from Bend 2	2,596 [c]	32%	18,247
Amount from excess over Bend 2	0	15%	
Total PayGo Benefit, monthly	5,320		
Annual OASI Benefit in 2047 dollars	63,842		

[a] 4,678,689 / (35 years * 12 months/year)
[b] 3,027 * 90%
[c] (11,140 – 3,027) * 32%

Online Appendix C: Sample Calculation of Cohort Annuity (8.8% Savings Rate)

Table C1: Cohort Savings during work years

Year	Age	Cohort N	Portfolio Return	Total Cohort Savings	Total Annuity Payment	Cohort Total PRA
2000	21	3615	16.75%	3,300,223	--	3,300,223
2001	22	3612	18.36%	4,225,771	--	8,131,970
2002	23	3611	23.13%	5,381,087	--	15,393,759
2003	24	3606	10.95%	6,438,896	--	23,518,917
2004	25	3603	22.30%	7,542,349	--	36,306,888
2005	26	3598	0.84%	8,632,956	--	45,244,130
2006	27	3595	27.45%	9,682,988	--	67,348,752
2007	28	3592	12.16%	10,501,959	--	86,042,833
2008	29	3588	4.50%	11,114,282	--	101,025,914
2009	30	3586	-13.72%	11,775,730	--	98,938,487
2010	31	3583	-20.59%	12,214,057	--	90,785,306
2011	32	3575	-15.86%	13,013,935	--	89,400,290
2012	33	3568	-14.19%	13,170,567	--	89,885,022
2013	34	3562	-6.85%	13,870,804	--	97,597,806
2014	35	3555	-15.91%	14,914,659	--	96,983,835
2015	36	3551	8.50%	15,384,971	--	120,617,084
2016	37	3548	2.10%	16,097,918	--	139,242,550
2017	38	3539	-12.72%	17,073,204	--	138,605,867
2018	39	3533	-9.55%	17,441,156	--	142,808,954
2019	40	3526	8.51%	18,495,693	--	173,461,647
2020	41	3522	-3.92%	19,442,697	--	186,102,036
2021	42	3517	47.52%	20,000,017	--	294,538,472
2022	43	3510	-8.58%	21,234,022	--	290,504,192
2023	44	3496	-9.49%	21,802,575	--	284,747,708
2024	45	3489	-20.68%	22,455,277	--	248,311,547
2025	46	3485	11.18%	23,585,815	--	299,669,917
2026	47	3481	-3.63%	24,397,277	--	313,202,337
2027	48	3472	36.22%	25,661,982	--	452,317,328
2028	49	3456	-7.13%	26,530,003	--	446,611,882
2029	50	3444	-2.62%	27,097,232	--	462,002,408
2030	51	3436	9.94%	27,945,051	--	535,848,442
2031	52	3421	-6.93%	27,611,668	--	526,346,771
2032	53	3408	0.15%	28,085,375	--	555,221,836
2033	54	3396	0.79%	28,088,451	--	587,714,342
2034	55	3380	-11.18%	26,979,316	--	548,993,869
2035	56	3365	6.49%	27,322,697	--	611,948,542
2036	57	3343	11.18%	26,836,619	--	707,179,781
2037	58	3329	10.62%	26,077,880	--	808,364,026
2038	59	3309	-3.25%	25,995,430	--	808,113,973
2039	60	3282	1.60%	24,436,019	--	845,494,970
2040	61	3255	14.23%	23,490,589	--	989,335,541
2041	62	3229	8.80%	21,197,192	--	1,097,561,304
2042	63	3190	-5.77%	18,133,675	--	1,052,382,044
2043	64	3143	-2.69%	15,449,875	--	1,039,529,199
2044	65	3102	-2.88%	12,456,609	--	1,022,001,355
2045	66	3060	13.55%	10,315,508	--	1,170,797,981
2046	67	3017	7.02%	7,965,906	--	1,260,971,476

Table C2: Cohort Savings and Annuity Payments during Retirement Years

Year	Age	Cohort N	Portfolio Return	Total Cohort Savings	Total Annuity Payment	Cohort Total PRA
2047	68	2969	-15.96%	--	100,230,818	1,103,993,888
2048	69	2919	13.96%	--	107,431,292	1,150,633,235
2049	70	2866	22.38%	--	123,493,487	1,284,623,378
2050	71	2811	-7.70%	--	106,948,946	1,078,694,865
2051	72	2753	3.61%	--	103,823,556	1,013,819,853
2052	73	2691	32.40%	--	128,547,275	1,213,756,774
2053	74	2634	18.74%	--	142,932,549	1,298,281,482
2054	75	2565	12.36%	--	149,620,551	1,309,153,395
2055	76	2495	-4.59%	--	132,837,922	1,116,180,378
2056	77	2421	25.21%	--	154,407,913	1,243,209,316
2057	78	2339	34.00%	--	191,240,989	1,474,666,470
2058	79	2252	11.00%	--	195,525,723	1,441,325,408
2059	80	2165	4.41%	--	187,760,760	1,317,126,918
2060	81	2076	-11.75%	--	152,006,011	1,010,364,882
2061	82	1979	9.37%	--	151,621,032	953,447,232
2062	83	1879	-8.72%	--	125,716,876	744,606,064
2063	84	1764	5.82%	--	119,478,216	668,438,908
2064	85	1640	-5.69%	--	100,221,578	530,183,329
2065	86	1521	7.07%	--	95,213,237	472,471,758
2066	87	1392	31.51%	--	109,628,260	511,700,771
2067	88	1258	3.89%	--	98,473,031	433,145,454
2068	89	1131	1.84%	--	86,256,676	354,864,423
2069	90	1003	32.57%	--	97,016,386	373,426,745
2070	91	881	25.85%	--	102,596,093	367,348,653
2071	92	764	-13.76%	--	73,402,163	243,386,520
2072	93	655	-1.92%	--	59,046,450	179,659,991
2073	94	559	5.21%	--	50,721,994	138,300,728
2074	95	464	2.08%	--	41,116,002	100,060,844
2075	96	372	-12.14%	--	27,708,841	60,209,059
2076	97	301	6.39%	--	22,819,221	41,235,532
2077	98	244	1.48%	--	17,958,681	23,887,180
2078	99	190	-0.61%	--	13,297,221	10,444,827
2079	100	156	-3.63%	--	10,065,423	0